Executive Summary

Propulsion Plant Standards Feasibility Study

U.S. DEPARTMENT OF COMMERCE
MARITIME ADMINISTRATION

IN COOPERATION WITH
BATH IRON WORKS CORPORATION

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1. BACKGROUND

To help U. S. shipyards meet the challenge of reduced subsidy rates as set forth in the Merchant Marine Act of 1970, the Maritime Administration initiated a U. S. Shipbuilding Research Program as a joint Industry/Maritime Administration venture. The Ship Producibility Program is a key element of the total National Shipbuilding Research Program, with its overall objective being to develop technical information which can be used effectively by U. S. shipyards to reduce the time and cost of building ships.

This report presents the results of Task S-1, Feasibility Study of Propulsion Plant Standards, which is one of the priority tasks in the Ship Producibility Program.

The study was conducted by M. Rosen blatt and Son, inc. under subcontract from the Bath Iron Works.

The duration of the study was about one year. The study was completed in April 1975.

2. A STUDY OF STANDARDS IS IMPORTANT AT THIS TIME

The Propulsion Plant Standards Feasibility Study was among the top priority tasks. This study was undertaken to determine the potential benefits and problems associated with the application of propulsion plant standards to shipbuilding in the United States. The obvious questions which might be asked are, "What prompted the study and why is it significant at this time?"

At the Annapolis Ship Producibility Planning Conference held in 1973, senior personnel from twelve U. S. shipyards defined potential Ship Producibility tasks which offered significant economic benefits. The Propulsion Plant Standards Feasibility Study was among the top priority tasks.

It is also significant to note that many of the major Japanese and European shipbuilders have devoted considerable effort to the development of standards for ship systems and components. They are enthusiastic about the resultant benefits which include simplified procurement, lower costs (both purchase and installation), and shorter design and building schedules. As the more progressive foreign shipbuilders found significant benefits, it appeared likely that the U. S. shipbuilders could do so too. Clearly, the U. S. shipbuilders could benefit from simplified procurement methods, lower costs, and shorter building periods if these results could be achieved at reasonable cost.

The study is most significant at this time because U. S. shipbuilding is at a critical juncture. The Merchant Marine Act of 1970 expanded the total market for ships by making bulk carriers eligible for construction differential subsidies. At the same time, it put a challenge to U. S. shipbuilders to lower the cost of their product and increase their marketing efforts, emphasizing series production of ship designs that were engineered

for low cost production. After several years of expanding order books, the world shipyards are now booking few ships. The likely result will be more competitive pricing which will affect the U.S. shipbuilders directly or indirectly. Delivery times are critical to both owners and shipbuilders. When a ship owner sees an opportunity to offer a special service to shippers, he wants to act quickly and obtain ships as soon as possible. He must act before the world economic picture changes or some other ship owner seizes the advantage. Therefore, reduced shipbuilding times can be very beneficial to ship owners, and it follows that shorter schedules can be very advantageous to a shipbuilder both in obtaining an order and in achieving more production from a given facility. In summary, these pressing reasons led the shipbuilding community and the Maritime Administration to the conclusion that they should initiate a study of the potential benefits of applying standards to shipbuilding in the United States.

3. THE OBJECTIVES AND SCOPE OF THE STUDY

The purpose of the study was to assess the technical and economic feasibility of the development, industry-wide acceptance, and implementation of propulsion plant standards from the viewpoint of reducing the cost and time of shipbuilding in the United States. The study was to answer the question, "Can standards for propulsion plants benefit ship producibility?" A further objective of the study was to determine the type and level of standards appropriate for systems and subsystems of a propulsion plant and then to consolidate the standards into logical groups. Standards for both the software and hardware of propulsion plants were to be considered, and skeleton formats were to be prepared for the proposed standards. Once the technical feasibility was evaluated, the standards were to be submitted to a comprehensive economic analysis. The economic analysis was to give equal consideration to dollar savings and time savings in the design, procurement, and installation of machinery.

The overall objective of the study was to conclude whether the shipbuilding industry should pursue development of standards for propulsion plants. If an affirmative conclusion resulted, the study team was required to recommend a plan for the initiation of the standards development program.

The scope of the work was set by limiting the study to the propulsion machinery for those commercial cargo carriers of 10,000 DWT and above likely to be built in the United States over the next decade.

4. THE APPROACH INVOLVED FORECASTING SHIPBUILDING PLUS SELECTION AND EVALUATION OF CANDIDATE STANDARDS

The overall approach was designed to uncover industry-wide problems related to the acquisition and installation of propulsion plants, which might benefit from the application of standards. The investigators had extensive interviews with ship owners, shipbuilders, and machinery manufacturers. The project team also received valuable

advice from the Project Advisory Council which was formed to make periodic review of the project. The Council members were a rich reservoir of experience in standardization and ideas on the future application of standards.

The study consisted of three primary tasks:

- A forecast of shipbuilding and related propulsion system requirements for the next ten years
- Selection and definition of candidate standards
- Evaluation of the potential benefits of applying the several candidate standards to propulsion machinery

5. AN ESTIMATE WAS MADE OF THE SHIPS THAT WOULD BE CONTRACTED FOR DURING THE TEN-YEAR FORECAST PERIOD AND THEIR PROPULSION PLANT NEEDS

Approximately 350 U. S. built ships are projected for the period 1976 through 1985. There are a number of economic and political factors which could raise or lower this level, but it provides a sufficiently valid base for estimating the approximate number of power plants that will be required: The projected ships would require about 185 steam turbine propulsion plants of varying steam cycles, approximately 110 gas turbine propulsion plants of heavy-duty and/or aircraft derivative types, and some 75 diesel propulsion plants composed of single or multiple medium-speed diesel engines.

The steam turbine, gas turbine, and the medium-speed diesel propulsion plants were each technically analyzed by developing a work breakdown structure showing all equipment comprising the plant at the total package, major systems, major equipment/subsystems, and equipment/component levels.

6. FOUR GROUPS OF STANDARDS WERE DEFINED

The performance, operating, interface, packaging and software requirements for each system, subsystem, or equipment were considered individually, and the parameters suitable for inclusion in a standards development program were established on the basis of technical feasibility, qualitative economic potential, and industry acceptance.

The systems and equipments which lent themselves to being included in the standards program were listed in matrices together with the standard parameters. A careful review of these matrices showed that the same parameters appeared at various levels of detail. Consequently, the common parameters were combined within the functions of the standards candidates to which they belonged, and four groups of standards resulted. The title of each group indicates how much of the propulsion system is covered by the standard.

The four groups are as follows:

- **Group 1 — Total Propulsion Plant Standards**
- **Group II — System/Equipment Module Standards**
- **Group III — Equipment Envelope Standards**
- **Group IV — Individual Equipment/Component Standards**

It was concluded that three steps should be considered within the fourth group:

- **Data Standards**
- **Procurement Standards**
- **Hardware Standards**

The definitions and objectives of the four groups are contained in the following paragraphs.

Group 1 — Total Propulsion Plant Standards

The Group I Standards are documents that contain the technical information (in standard format) necessary to define and describe machinery which collectively forms a propulsion plant which has a finite horsepower range. Within each standard horsepower range, the definition covers the performance, type, description, and operating characteristic of the propulsion system including its principal subsystems.

For example, the system definition is carried to the level of sized system piping diagrams for each horsepower range selected.

The objectives of Group I Standards are to achieve a systematic, consistent approach to power plant design which would lead to reduced contract and detail design costs and shortened shipbuilding schedules.

Group II — Equipment/System Module Standards

Group II Standards are documents which contain the technical data and information required to define and describe complete subsystems or groups of equipment that are mounted on a common base. The Group II Standard includes performance, type, description, and operating characteristics of the module. These standards also prescribe size and location of interfaces plus limiting dimensions and weights for a given module.

The objectives of Group II Standards are to achieve reduced installation time and costs, as well as reduced test and checkout time. The modules permit interchangeability without imposing dimensional constraints on equipment.

Group III — Equipment Envelope Standards

Group III Standards are documents containing the technical data and information required to define and describe the performance and interface characteristics of equipment so that equipment of like characteristics from different vendors may be used interchangeably. These standards consist of imaginary envelopes which surround the equipment in question. This concept limits overall size and weight of the envelope and determines interface and installation requirement sizes and locations for that particular equipment independent of vendor source. These standards **will be such that all eligible vendors will be able to meet the requirements of the standard by using a sub-base and adding inter-connections between an item of equipment and its various interfaces.**

The objective of this standard is to achieve the shipyard benefits of Hardware Standards without imposing the constraints on **manufacturers that would be necessary for Hardware Standards.**

Group IV — Individual Equipment/Component Standards

This standard is subdivided into three distinct types of standards which may be considered as steps of a phased approach to the ultimate hardware, or equipment, standard.

The Data Standard **is a document which contains technical information (in standard format) pertaining to vendor equipment required for propulsion machinery. The technical information included is that which is necessary for ship designers to perform propulsion plant designs at any level (preliminary design, contract design or detail design) without requiring additional information such as validated vendor drawings and specifications.**

The major objective of this standard is to provide the designer with certified equipment design data at the time the contract design is started. This eliminates the time-consuming process of requesting, obtaining, and evaluating owner and regulatory body approvals of vendor plans and specs before release for manufacture. The second objective is to eliminate the design changes usually incurred by the continuous updating of vendor data during a normal ship design cycle.

The Procurement Standard **is a document containing the information required to purchase ship propulsion equipment from vendors. This document contains both the technical documentation and legal documentation. The legal portion of this document contains the purchase terms and conditions. The technical portion contains the data prescribed by a Data Standard.**

The principal objective of this type of standard is to reduce the cost and schedule time of procurement and installation of the equipment, including ship design tasks.

The Hardware Standard is a document containing the technical information necessary to define and describe hardware which would be interchangeable between any vendor. Interchangeable, in this standard, means like equipment of a given capacity will have identical — within specified limits — performance characteristics, interface dimensions, size limitations, weight, mounting dimensions, and compatibility of materials.

The several objectives of this standard include those of the Data Standard in that basic data would be available in a timely order. In addition, use of this standard would facilitate interchangeability with the added benefit of buying components from several vendors without design changes and reducing operational maintenance costs.

7. THE TOTAL PROPULSION PLANT STANDARD (GROUP I) OFFERS THE GREATEST LONG-TERM POTENTIAL AND PROCUREMENT STANDARD (GROUP IV) OFFERS THE GREATEST NEAR-TERM POTENTIAL

The results of the technical analyses were compiled in a tabulation which showed the potential standards candidates in each group. A representative sampling of standards candidates was then selected for quantitative economic analyses.

For each of the four groups of standards, a format was prepared which listed all the parameters that would be standardized, and their interrelationship with the systems and the plant in general. These formats were used as a basis for the subsequent economic analysis of each standard.

In performing the specific economic analyses, a methodology was followed to provide simplicity and uniformity in the calculations and evaluations. It involved estimating the costs and schedule times associated with the method of production currently being used in most U. S. shipyards (the existing approach) and comparing these against the costs and schedule times for the method of production which would be used if the proposed standards were implemented (the standards approach).

The numerical evaluations obtained from the economic analyses were summarized in a comprehensive tabulation.

The summary evaluation of the four types of standards is as follows:

Total Propulsion Plant Standards (Group 1)

These standards appear to have good potential and are recommended for implementation. They should be carried to a level of detail of heat balances and sized system diagrams in the initial stage of development. Because they are the most comprehensive, they may be more difficult to implement.

Systems/Equipment Modules Standards (Group II)

These standards, although viable, will probably develop only as a result of implementation of a Group I Total Propulsion Plant Standards Program. Due to the shipbuilder's preference to design custom modules for facility equipment suppliers, development of these standards should be deferred.

Equipment Envelope Standards (Group III)

These standards were presented to several equipment manufacturers and the response was positive. Ship designers, however, were generally not **in favor of this concept. The Equipment Envelope Standard would permit use of similar equipment from various vendors upon a standard base or foundation with standardized interface sizes and locations exterior to those of the basic equipment. Ship designers were apprehensive of the increased envelope size required for the standard and the possible additional stress analysis required. Use of these standards would permit a shipyard to proceed with design of the ship prior to selection of the manufacturer. It is recommended that developing this type of standard be deferred, but further investigation is warranted concentrating on equipment whose overall size is non-critical relative to the available space in the engine room and the location of the equipment.**

Individual Equipment/Component Standards (Group IV)

Step 1: Data Standards

Affords the designer the convenience of having the required equipment design data ready when needed. It is an important step toward development of procurement standards. As procurement standards contain data package as well, it is recommended that Data Standards not be developed separately.

Step 2: Procurement Standards

This type of standard is relatively easy to develop; it has the potential to provide significant savings, and it requires no changes in individual vendor's equipment. For these reasons, it is recommended that Procurement Standards, including Data Standards at vendor plan level of detail for each component, be developed and implemented.

Step 3: Hardware Standards

The Hardware Standards, if developed and implemented, promise savings not only in initial installation costs, but also in maintenance costs. However, they may interfere with the design philosophy of individual manufacturers and may necessitate substantial changes in their designs. Many manufacturers have already standardized their product lines within

company boundaries. They indicated that they require freedom of design to maintain their competitive edge. Hardware Standards would probably be the most difficult type to develop and implement. For these reasons, it is recommended that the development of hardware standards be deferred and only Procurement Standards (including Data Standards) be developed in Group IV.

General

The Data Standard (developed with the Procurement Standard) could first present the desired standardized characteristics, operating conditions, materials, dimensions, and other special features of the class of component. This is the specification towards which it is desired the standardization would proceed as new designs are developed or old designs modified. Interchangeability would be the ultimate end product. Section 2 of this standard would then present the data bank of available components on the market including in the proper format all of the pertinent features of each described unit in a manner parallel to the desired standard. The existence of such a Data Standard would form a solid base for developing Hardware Standards.

8. THE ECONOMIC BENEFITS OF APPLYING STANDARDS TO A STEAM PLANT COULD BE 15% OF PROPULSION PLANT ACQUISITION AND INSTALLATION COSTS

Conclusion

Significant economic benefits can result from the application of standards. These benefits stem from several factors. First, the selective use of standards can reduce the number of man-hours needed in both the contract design and the detail design. Second, they permit earlier initiation of the construction phase, reduce its overall time requirements, and can eliminate costly design changes that may result under the design, procurement, and production process used by U. S. shipyards which do not have an established ship product line.

The reduced shipbuilding times offer the shipyard the potential of higher facility utilization. These shorter times may also be an effective marketing advantage to a shipyard.

The most advantageous approach appears to be the use of Total Propulsion Plant Standards (Group I) in combination with the Procurement Standards of Group IV. The analysis indicated that the standards in combination could save about 4% of the direct costs and about 5 months of schedule time required for the procurement and installation of the propulsion plant. In many shipbuilding programs, the procurement and installation of the propulsion plant is a controlling item in the delivery of the ship. This is especially true

in the ship designs which have the house aft over the machinery spaces. Thus the adoption of these standards, if accompanied with suitable actions relative to the other parts of a ship, would permit a reduction of about 5 months in the delivery of the first ship of a class.

It is common knowledge that every day a ship remains under construction, there are ongoing costs of guards, power services, service trades, and supervision in addition to the cost of the facilities committed to a ship under construction. Based on Bath iron Works data for medium size ships, these daily costs were estimated to be between $5,000 and $10,000 per day per ship in most U. S. shipyards. Using the $5,000 per day per ship value, the 5 months earlier delivery of the first ship in a class could save a yard about $750,000 which would raise the total direct savings to about 15% of the propulsion plant acquisition and installation costs on the first ship of each class.

9. RECOMMENDED NEAR-TERM ACTIONS

Adoption of standards and realization of their potential savings can only be achieved when the shipyard managers are convinced that the potential results indicated in this report are achievable in their yards. Only then will they be likely to apply the amount of top management attention that will be needed to overcome the early resistance of some owners, suppliers, or shipyard executives.

It is recommended that a pilot program be initiated for developing one Total Propulsion Plant Standard and one or more Procurement Standard with associated Data Standards for each equipment supplier's component. These standards should then be applied to a new shipbuilding program in two or more U. S. shipyards to test the ability of standards to reduce propulsion plant costs and determine if the shipyards involved find the concept acceptable. The specific plant and components for each standard would be selected by the Propulsion Plant Standards Advisory Council or some other industry committee such as the SNAME Ship's Machinery Committee. The shipyard managers and other key maritime executives should be fully briefed on the results of this pilot program and the potential benefits of selective use of standards. If the pilot program confirms the projected benefits and feasibility, the program for implementation of standards should be continued to cover all Group I Total Propulsion Plant Standards and all Group IV Component Procurement Standards.

Both the shipyard managers and the Maritime Administration should give their continued support to the program because of its high potential pay-off to shipbuilders, ship owners, and the supplier industry.